ME 333 Experiments Vibration & Control

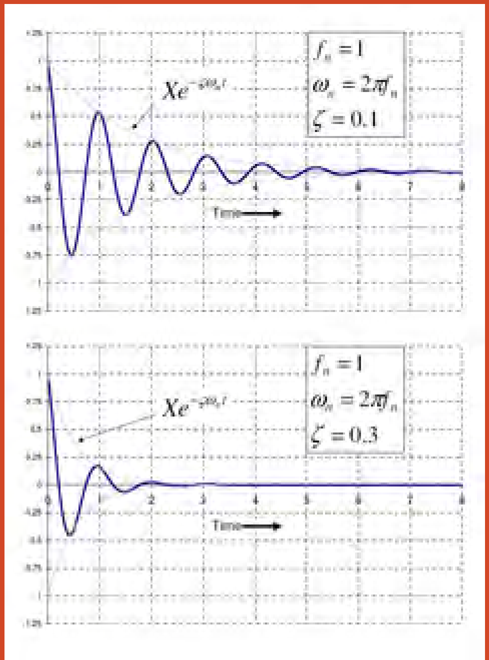
A. Vibration Laboratory

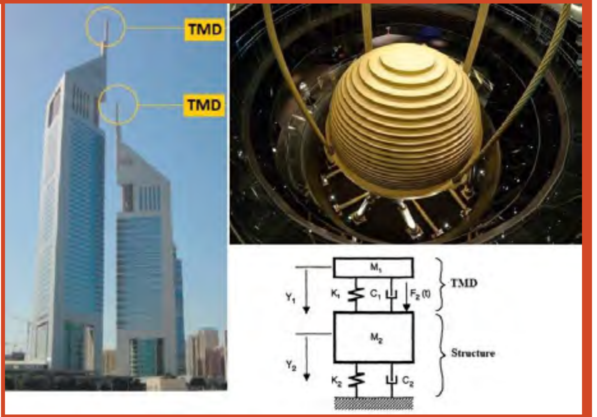
- Experiments
  - Free and Forced Vibration of Rigid Beam Spring Damper System
  - Transmissibility effect

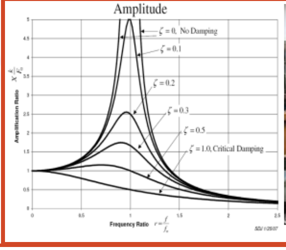
B. Control Laboratory

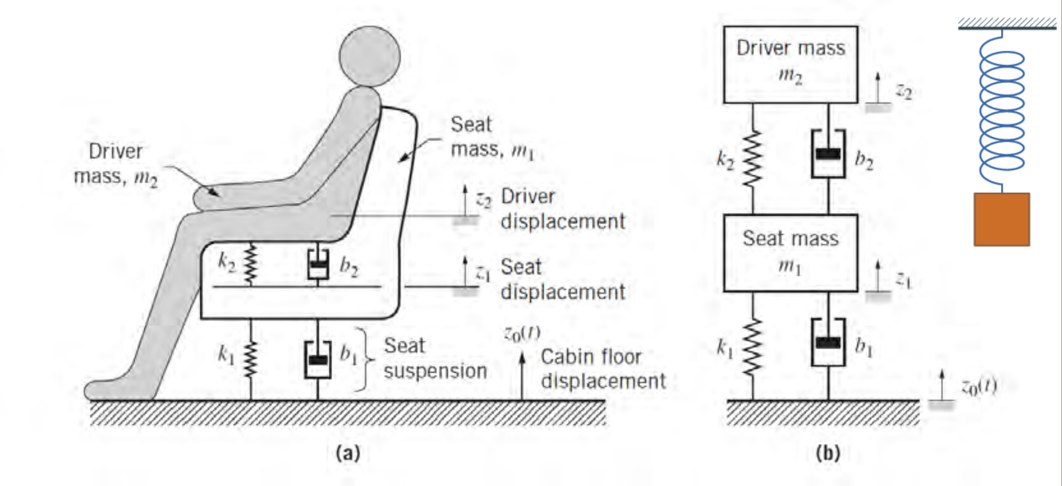
- Experiments
  - Speed torque Characteristics

    PID Controller and Magnetic Levitation - Demo
  - Speed Measurement of DC motor









Experiments - Vibration

Experiment 01

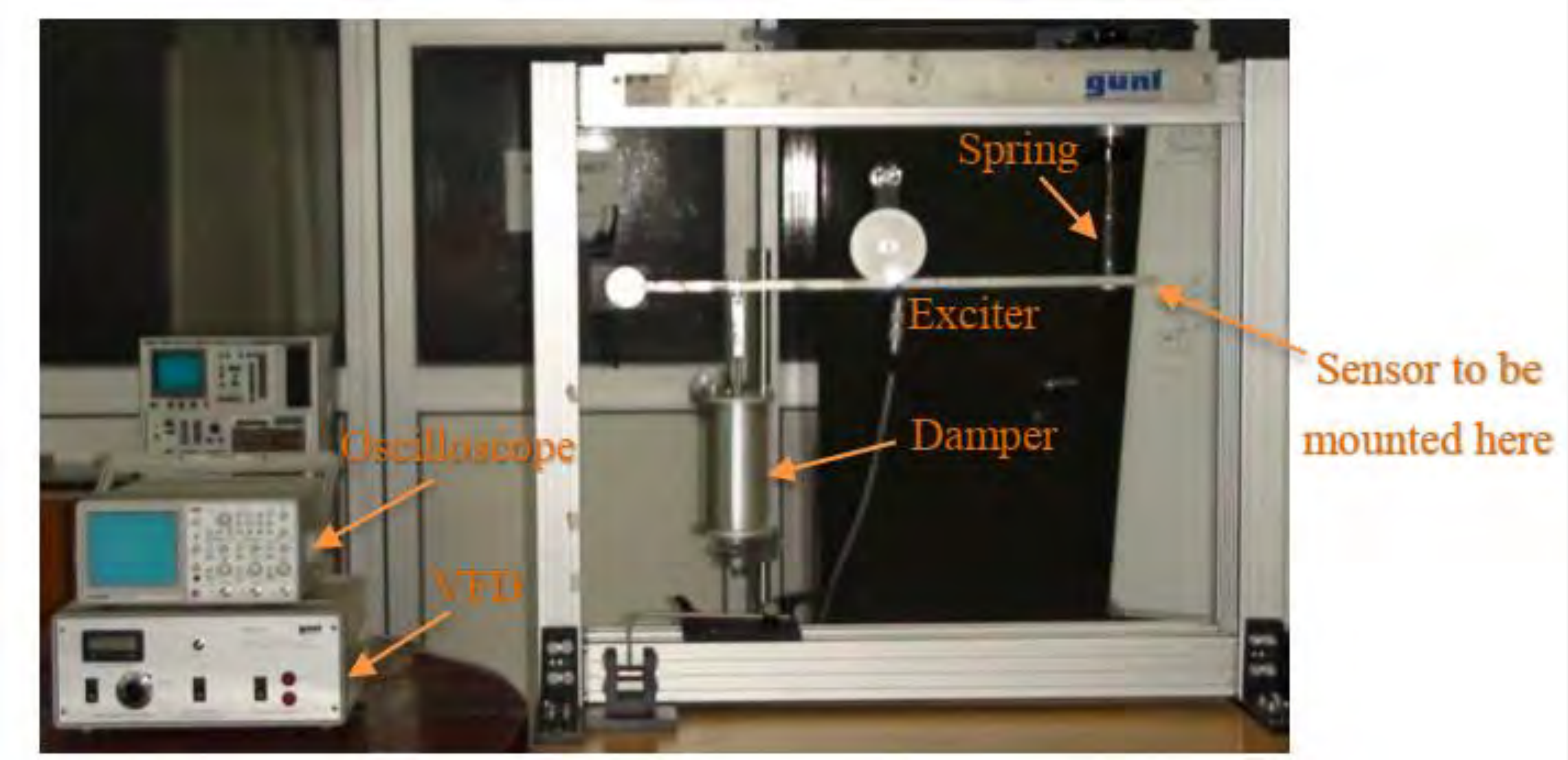
Free and forced and free vibration of a rigid beam-spring-damper system

Overview

The system is a “rigid” hinged beam, with a single degree of freedom, oscillating about its hinge. A spring and a damper are attached to the beam at two different locations.

The free vibrations are generated by displacing the beam from its equilibrium position and the forced vibrations are generated by an electrical motor-driven imbalance exciter.

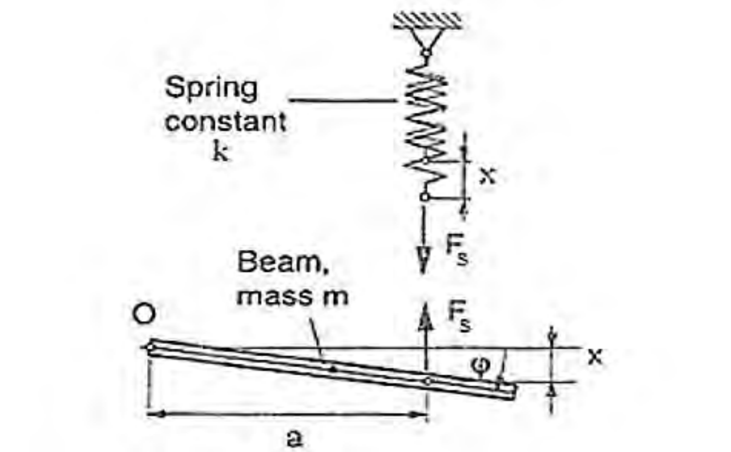
The exciter frequency can be set precisely using a VFD (variable frequency drive and an oil damper is used for vibration damping.

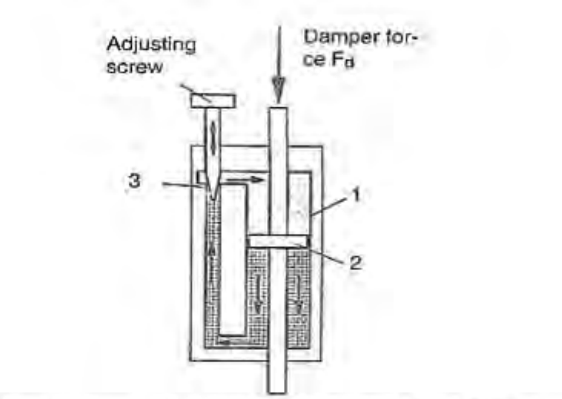


Experimental Setup

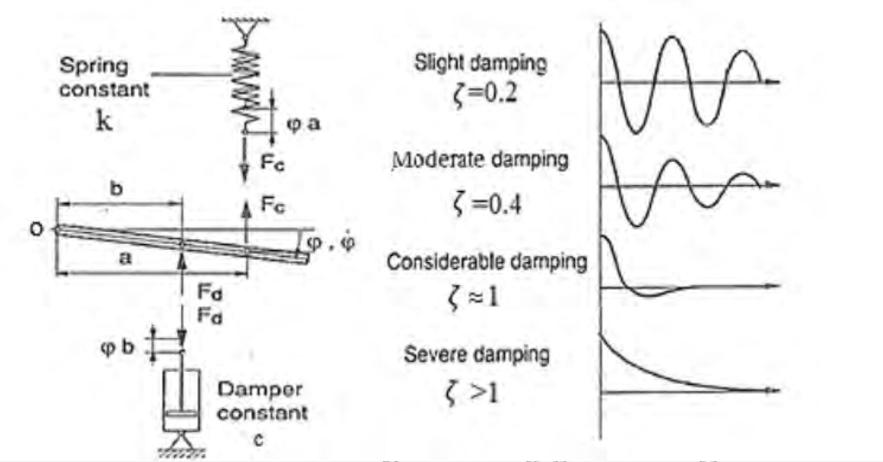
Free and forced and free vibration of a rigid beam-spring-damper system

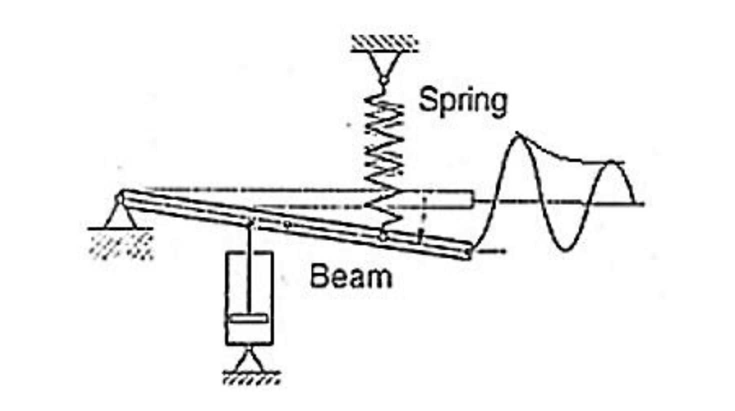
Frequencies of un-damped oscillation				
Experiment no.	Spring no., constant *k* in N/mm	Experiment		Theoretical frequency (Hz)
		Time period (sec)	Frequency (Hz)	
1	0.75	0.2	5	5.18
2	1.50	0.142	7.04	7.38
3	3.00	0.0952	10.50	10.38





Procedure of adjusting damper settings





Experiment 02

Vibration transmissibility of a single degree of freedom system

Overview

This experiment focuses on the response of a single degree of freedom system put on a base, which is excited with a constant amplitude sinusoidal displacement through a motor. The mass moves in one direction only (vertical). The acceleration of the mass is measured using a piezo sensor. The piezo sensor is connected to a charge amplifier and then to an oscilloscope, which displays the motion of the mass in terms of voltage. This voltage can be converted to displacement in *mm*.

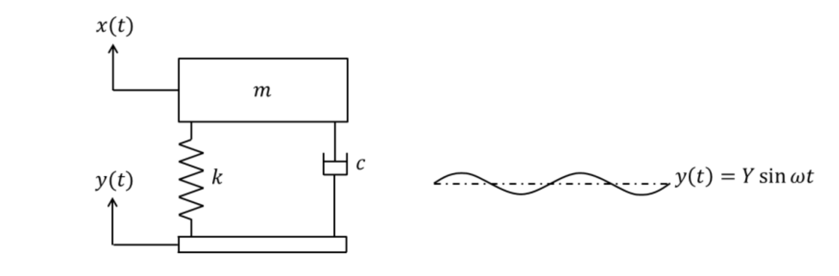


Figure 1: Spring mass dashpot system with base excitation

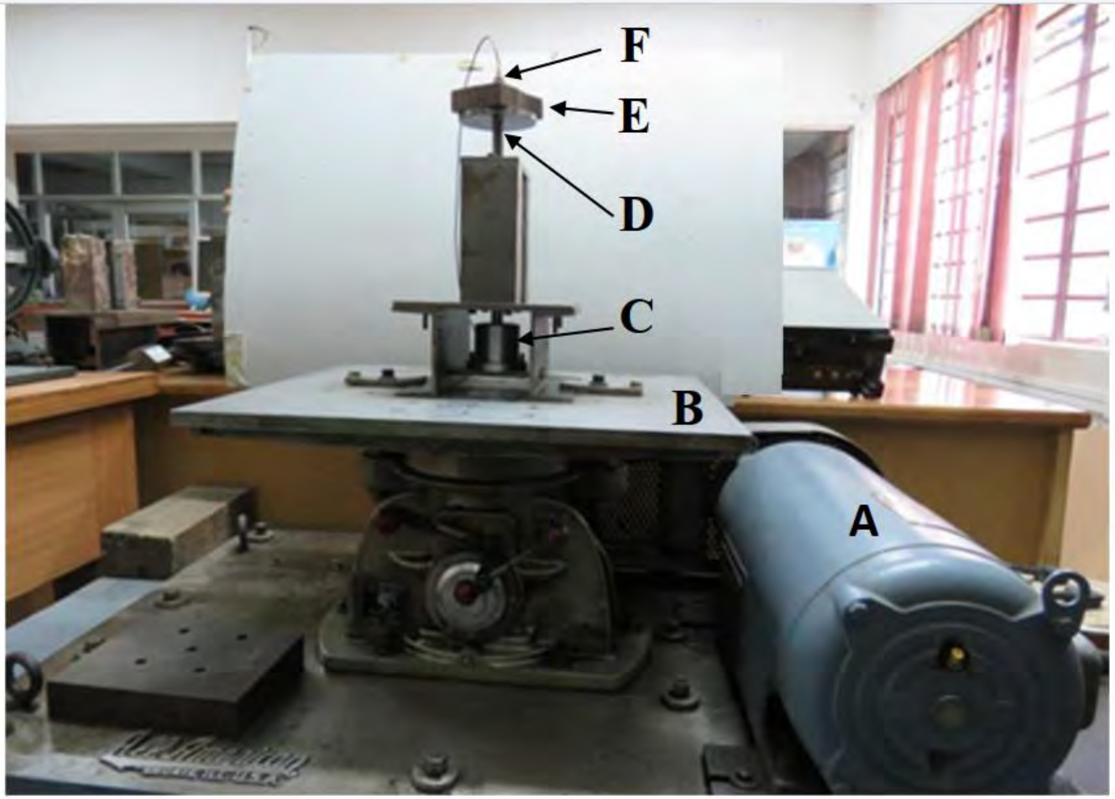


Figure 1: Experiment setup. (A) Motor (B) Base (C) Viscous damper (D) Primary mass system (E) Added extra mass (F) Piezo sensor.

Vibration transmissibility of a single degree of freedom system

Aim is to study the transmissibility of the vibrations from the base to the mass. So, we record the vibration amplitude of the mass for different frequencies of base excitation.

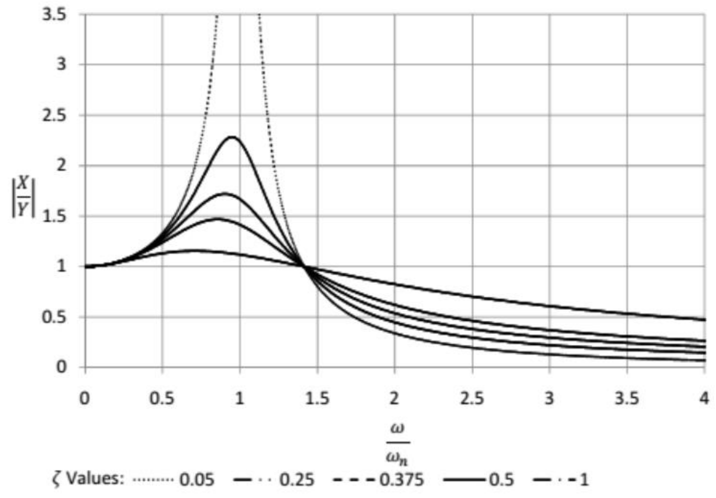


Figure 3: Amplitude ratio vs. frequency ratio

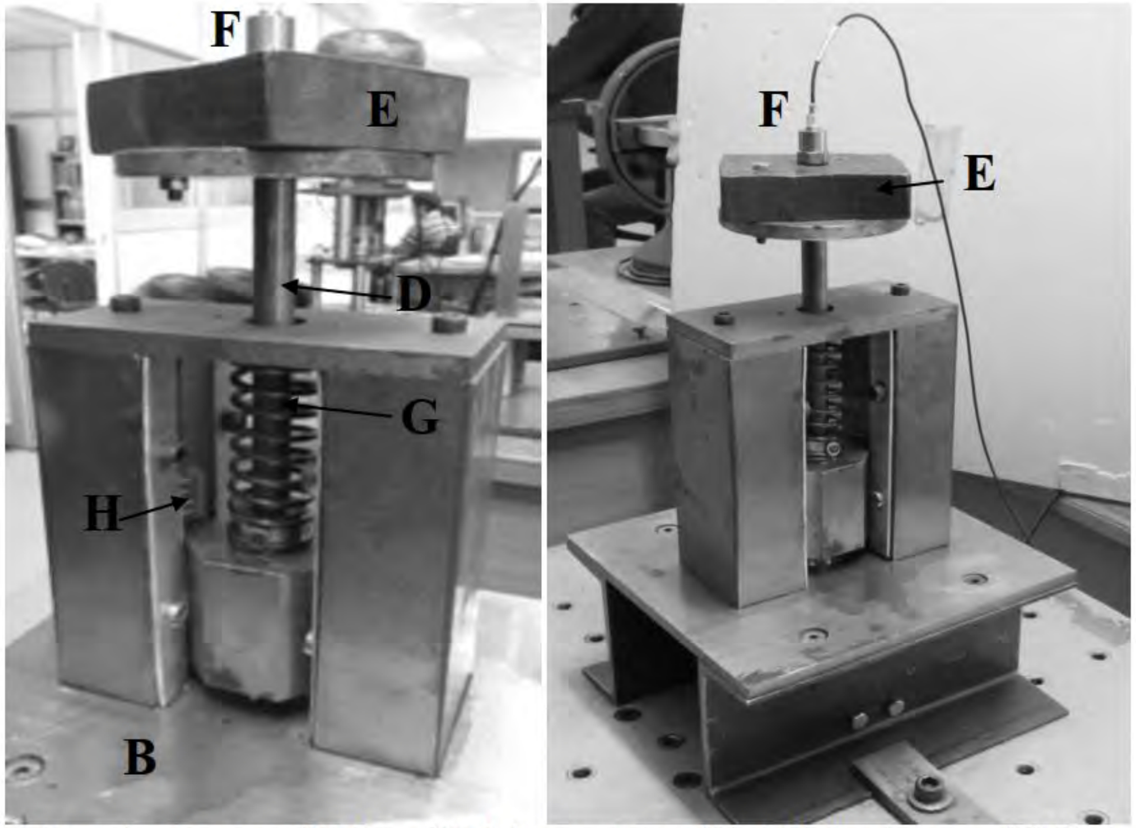


Figure 2: Experiment setup. (B) Base (D) Primary system (E) Added extra mass (F) Piezo sensor (G) Spring (H) Linear bearing.

Experiments - Control

Experiment 03

Speed measurement of DC motor using various Sensors

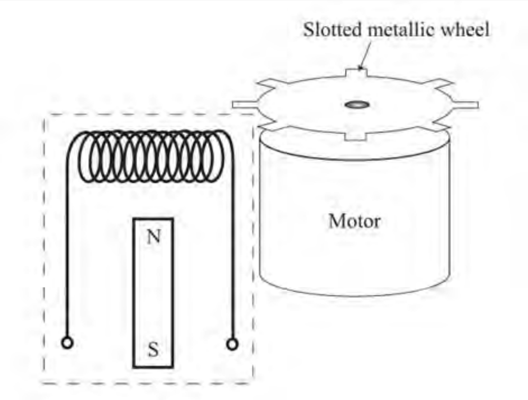
- 12V DC motor with speed varying from 0-4000 rpm & rotating slotted wheel having eight slots
- Individual signal conditioning circuit with programmable threshold comparator
- Frequency to Voltage Converter with span and zero amplifier

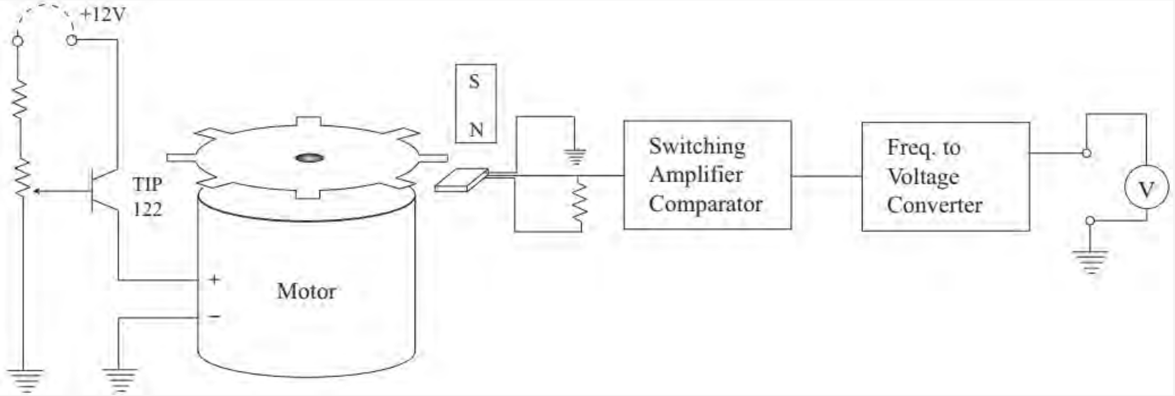
- All the sensors are placed in the vicinity to a slotted wheel fitted to the motor shaft
- Slotted wheel causes interruption, thus causes some periodic generation of voltage
- The periodic signals are amplified, converted into pulses and these pulses are further converted into DC voltage by frequency to voltage converter.
- Converter output having passed through zero span amplifier can be measured as speed indication.

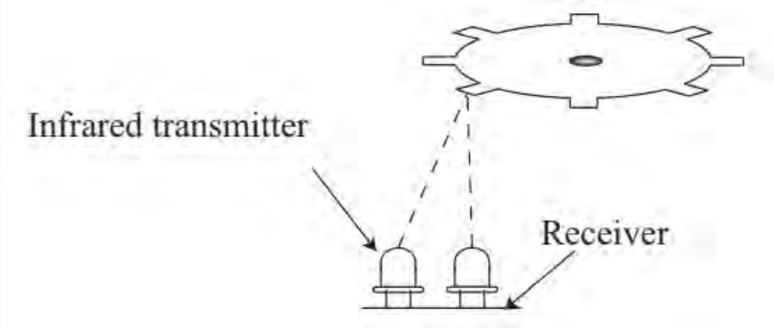
Speed measurement of DC motor using various Sensors

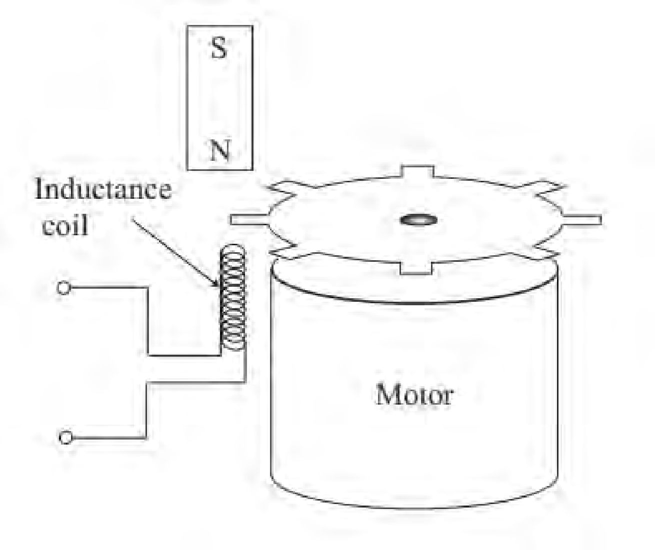
Six Speed transducers :

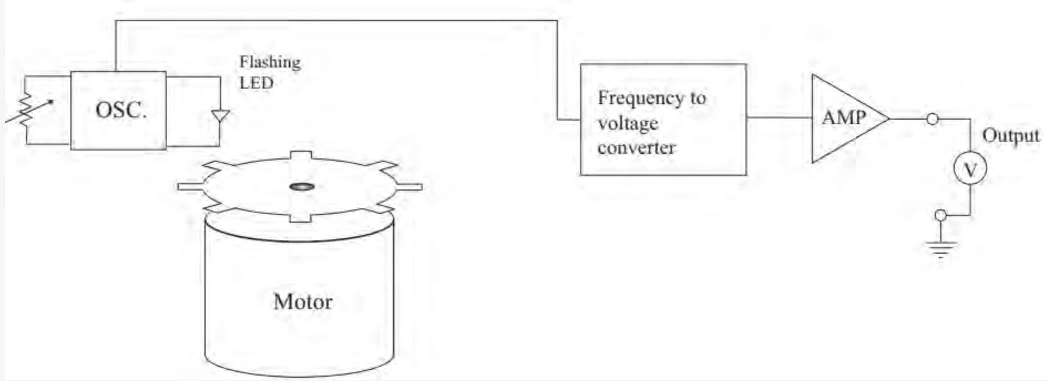
- 1) Magnetic pickup
- 2) Hall effect
- 3) Inductive pickup
- 4) Photo reflective
- 5) Photo interruptive
- 6) Stroboscopic Method

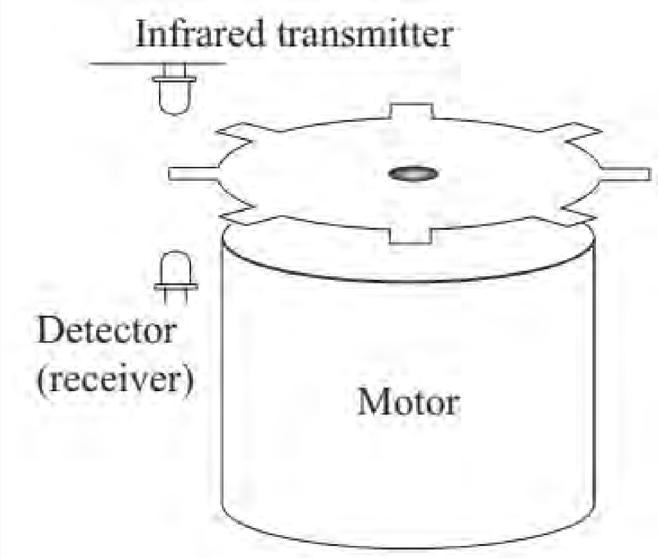












Experiment 04

(a) Speed torque characteristics of DC servomotor
(b) Measurement of linear displacement by potentiometer
(c) Demonstration of PID Controllers

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(a) Speed torque characteristics of DC servomotor
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(a) Speed torque characteristics of DC servomotor

(b) Measurement of linear displacement by potentiometer

Balancing of ball and beam system through PID control

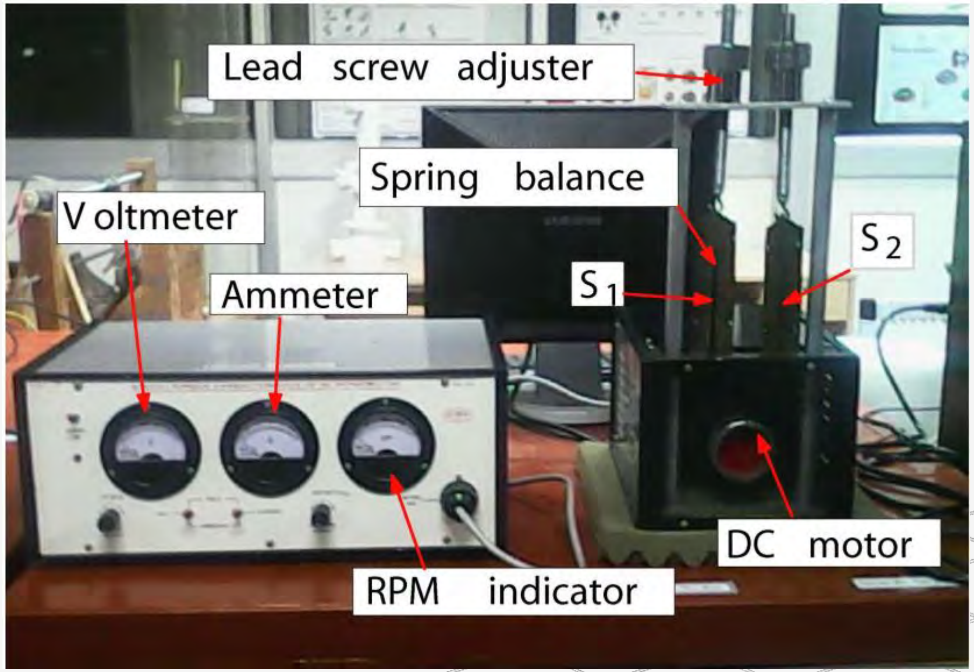
Balancing of Rotary Inverted pendulum through feedback control

(c) Demonstration of PID controllers

4(a) Speed torque characteristics of DC servomotor

The objectives of the experiment are following–

1. Verify the relationships given in Eqs. (1)-(2) from the experimental data.
2. Comment on the frictional torque developed in rotor
3. Plot I_a vs. T_m and ω_m vs. T_m curve



The relevant equations for the experiment are

$$T_m = K_m \phi I_a \tag{1}$$

$$T_m = \frac{K_m \phi}{R_a}(V_a - K_e \phi \omega_m) \tag{2}$$

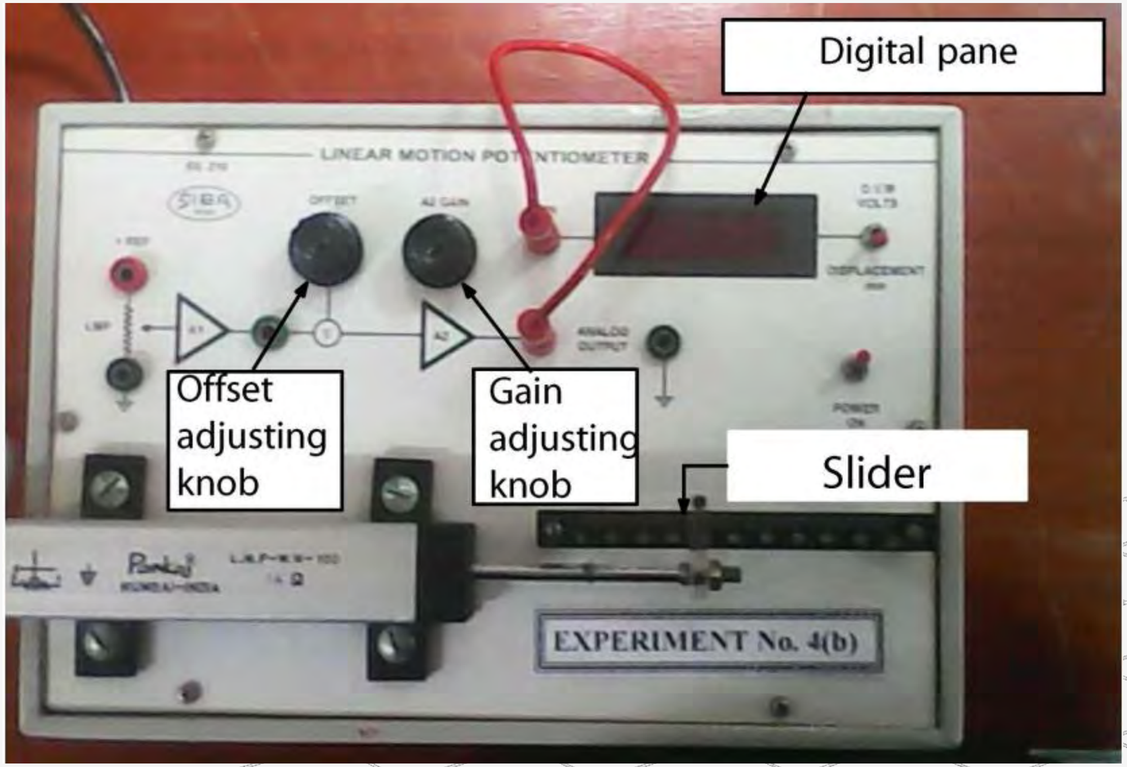
where T_m is the motor torque, ϕ is the magnetic flux (as a result of the field current set by the experimenter), I_a is the armature current, R_a is the armature resistance, e_b is the back emf, ω_m is the angular speed, K_m is a proportionality constant known as motor torque constant and K_e is a proportionality constant known as back emf constant.

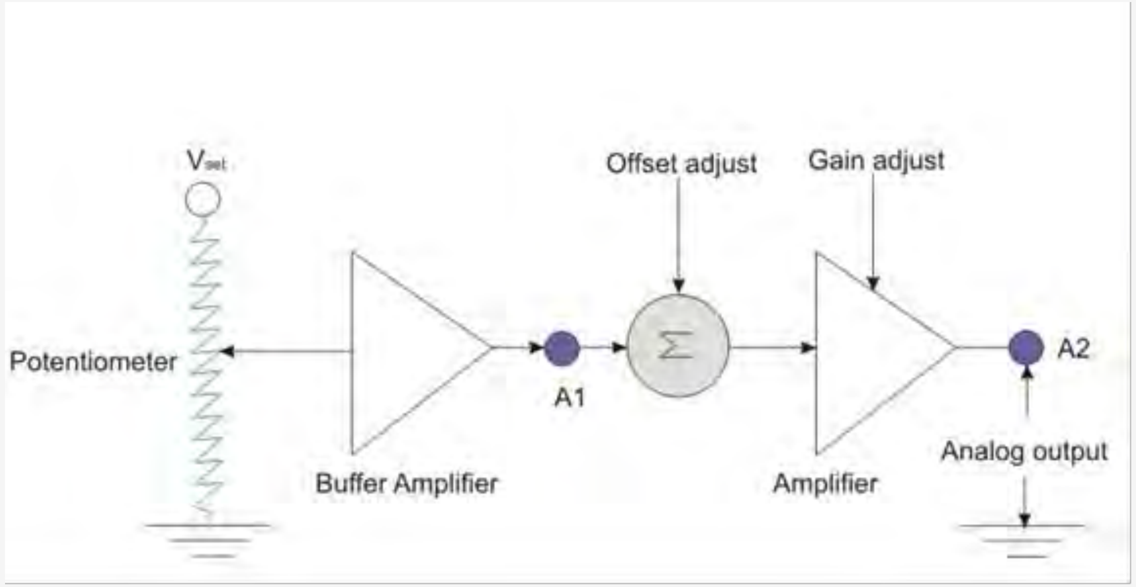
Torque $(T) = (\mathrm{S}_1 - \mathrm{S}_2) \times \mathrm{r}$

(a) Speed torque characteristics of DC servomotor

4(b) Measurement of linear displacement by potentiometer

Objective- To measure linear displacement by potentiometer and find out the hysteresis, linearity and systemic error of the Uncelebrated and Calibrated system.





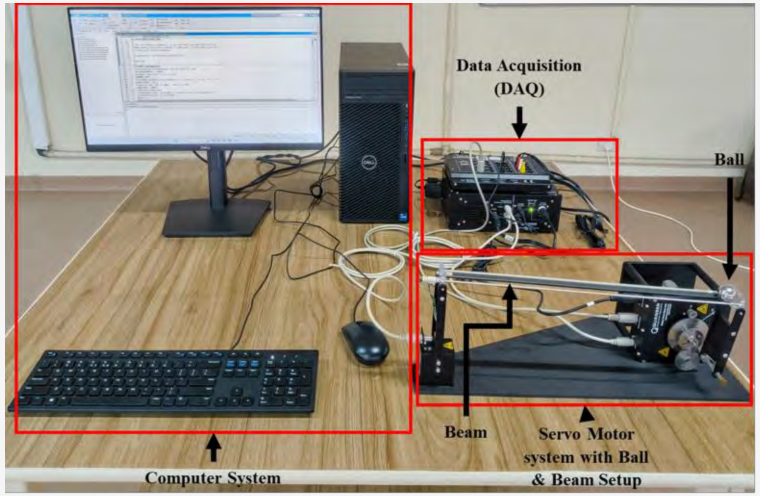
- Plot a graph between the displacement on DVM and output volts for Calibrated and Uncelebrated reading and D Vs d plot
- From the plot find out the slope of the curve as Sensitivity of the transducer given by:

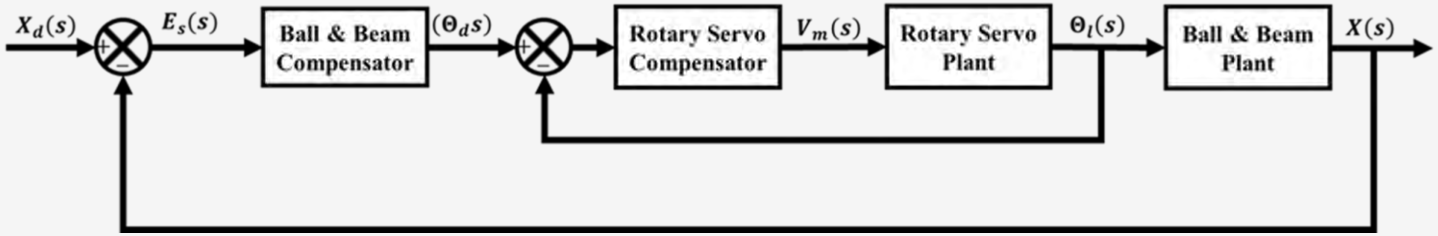
  SR = $\Delta V / \Delta d$, mV/mm.

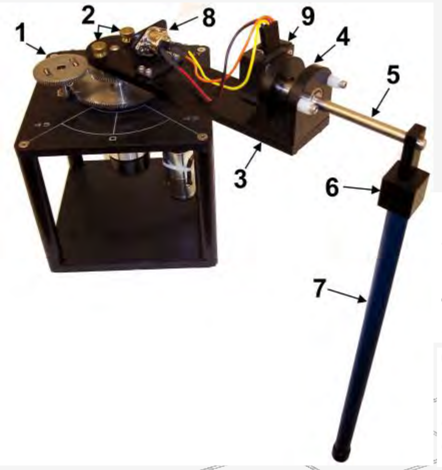
  ΔV = Voltage difference between two assigned point

(b) Measurement of linear displacement by potentiometer

4(c) Demonstration of PID Controllers







1	SRV02
2	Thumbscrews
3	Rotary Arm
4	Shaft Housing
5	Shaft
6	Pendulum T-Fitting
7	Pendulum Link
8	Pendulum Encoder Connector
9	Pendulum Encoder